

Scilab Textbook Companion for
Thermodynamics
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Book Description

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Scilab numbering policy used in this document and the relation to the above book.

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

AP Appendix to Example(Scilab Code that is an Appednix to a particular Example of the above book)

For example, Exa 3.51 means solved example 3.51 of this book. Sec 2.3 means a scilab code whose theory is explained in Section 2.3 of the book.

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Chapter 1

Fundamentals Concepts and Definitions of Thermodynamics

Scilab code Exa 1.2 Absolute pressure

```
1 // Exa 1.2
2 clc;
3 clear;
4 close;
5 // Given data
6 Pvacc = 700; // mm of hg
7 Patm = 760; // mm of hg
8 Pabs = Patm - Pvacc; // mm of hg
9 disp(Pabs/760, "Absolute pressure in in kg/cm^2 is :")
   ); // as 1kg/cm^2= 760 mm of Hg
10 disp(Pabs*1.01325/760, "Absolute pressure in bar is :")
   ); // as 1.01325 bar = 760 mm of Hg
11 disp(Pabs*1.01325/760*10^2, "Absolute pressure in in
   kPa"); // as 1 bar = 10^2 kPa
```

Scilab code Exa 1.3 Tank pressure


```

1 //Exa 1.3
2 clc;
3 clear;
4 close;
5 // Given data
6 Patm = 101; // kpa
7 Rho = 13.6 * 10^3; // in kg per m^3
8 h = 250; // in cm
9 h = h*10^-2; // in m
10 g = 9.806;
11 p = Rho * g * h; // in N/m^2
12 p = p*10^-3; // in kPa
13 // Total pressure in tank
14 p = p + Patm; // in kpa
15 p = p*10^-3; // in Mpa
16 disp(p, "Total pressure in tank in Mpa");

```

Scilab code Exa 1.4 Work done by the piston

```

1 // Exa 1.4
2 clc;
3 clear;
4 close;
5 // Given data
6 m = 1.5; // in kg
7 pi = 0.1; // in MPa
8 pi = pi*10^6; // in Pa
9 pf = 0.7; // in MPa
10 pf = pf*10^6; // in Pa
11 rho_i = 1.16; // kg per m^3
12 vi = m/rho_i; // in m^3
13 WorkDone = pi*vi*log(pi/pf); // in J
14 disp(WorkDone*10^-3, "Work done in kJ is : ")
15 if WorkDone < 0 then
16 disp("The -ve sign indicates work is done on the

```

```

    system, hence");
17 disp((WorkDone*10^-3),"The work done by the piston
    in kJ is : ")
18 end

```

Scilab code Exa 1.5 Work done

```

1 // Exav1.5
2 clc;
3 clear;
4 close;
5 // Given data
6 p = 1.0; // in Mpa
7 p = p*10^6; // in N per m^2
8 del_v = 1.5; //m^3 per min
9 del_v = del_v*60; // m^3 per h
10 W = p * del_v; // W stands for work done in J
11 W = W*10^-6; // in MJ
12 disp(W,"Work done by the pump upon the water in an
    hour in MJ is : ");

```

Scilab code Exa 1.6 Height from which the mass should fall

```

1 // Exa 1.6
2 clc;
3 clear;
4 close;
5 // Given data
6 // W = 2*g*h
7 // due to stirring of water
8 g = 9.81;
9 J = 4.1868*10^3;
10 m = (0.2+10*10^-3)*10^3; // in gm

```

```

11 s= 1; // in cal per gm C
12 del_T = 2; // in C
13 H = m * s * del_T; // in cal
14 H = H*10^-3; // in kcal
15 // W = JH and W= 2*g*h
16 h = J*H/(2 * g); // in m
17 disp(h,"The height from the mass should be fall in
meter is :");

```

Scilab code Exa 1.7 Power of feed pump

```

1 // Exa 1.7
2 clc;
3 clear;
4 close;
5 // Given data
6 // mass of 1 liter of water is 1 kg. so
7 m = 5000; // in kg
8 h = 10-1; // in m
9 g= 9.81; //
10 PE = m * g * h; // in N m
11 PE = PE*10^-3; // in kj
12 Eta = 0.85;
13 // Eta = energy output/energy input
14 E_input = PE/Eta; // in Kj
15 E_input = E_input*10^3; // in J
16 t = 45; // time in min
17 t = t*60; // in sec
18 P = E_input/t; // in J/s
19 P = P*10^-3; // in kW
20 disp(P,"Power required for the feed pump in kW is :")
);

```

Scilab code Exa 1.11 Power of the engine

```
1 // Exa 1.11
2 clc;
3 clear;
4 close;
5 // Given data
6 V = 50; // km per hr
7 V = V * (1000/3600); // in m per sec
8 F = 900; // in N
9 P = F * V; // in watt
10 P = P * 10^-3; // in kW
11 disp(P, "Power of the engine of a car in kW is : ");
12 H = P * 60; // in kJ
13 disp(H, "Heat equivalent of work per minute in kJ is"
    );
```

Scilab code Exa 1.12 Power required

```
1 // Exa 1.12
2 clc;
3 clear;
4 close;
5 // Given data
6 E_air = 200-100; // in kJ/kg
7 E_lost = 40; // in kJ/kg
8 E_total = E_air + E_lost; // in kJ per kg
9 M = 0.5; // mass flow rate in kg per s
10 P = M * E_total; // in kJ/s
11 disp(P, "Power required for an air mass flow in kJ/s
    is :");
```

Scilab code Exa 1.13 Specific heat

```

1 // Exa 1.13
2 clc;
3 clear;
4 close;
5 // Given data
6 m_b = 1; // in kg
7 t_ib = 80; // in degree c
8 m_w = 10; // in kg
9 t_iw = 25; // in degree c
10 del_t = 5; // in degree c
11 S_w = 4.18; // in kJ/kg
12 t_equ = (t_iw + del_t); // in degree c
13 // Heat loss by metal = Heat gained by water
14 S_b = m_w * S_w * (t_equ - t_iw) / (m_b * (t_ib -
    t_equ)); // in kJ/kg-K
15 disp(S_b, "Specific heat of metal block in kJ/kg-K is
    ");

```

Scilab code Exa 1.15 Convert reading in kPa

```

1 // Exa 1.15
2 clc;
3 clear;
4 close;
5 // Given data
6 P_gauge = 90; // in cm of hg
7 P_atm = 760; // in mm of hg
8 P_atm = 76; // in cm of hg
9 P_abs = P_gauge + P_atm; // in cm of hg
10 P_abs = P_abs * (101.32/76); // in kPa
11 disp(P_abs, "Reading of pressure in kPa");
12 // Part (b)
13 P_vacuum = 40; // in cm of hg
14 P_abs = P_atm - P_vacuum; // in cm of hg
15 P_abs = P_abs * (101.32/76); // in kpa

```

```

16 disp(P_abs,"Reading of pressure to kpa");
17 // Part (c)
18 Rho = 1000;// in kg per m^3
19 g = 9.81;//
20 h = 1.2;// in m
21 P_gauge = Rho * g * h;// in N m^2
22 P_gauge= P_gauge*10^-3;// in kPa
23 P_atm = 101.32;// in kPa
24 P_abs = P_gauge + P_atm;// in kpa
25 disp(P_abs,"Reading of pressure in kPa");

```

Scilab code Exa 1.16 Depth of atmosphere

```

1 // Exa 1.16
2 clc;
3 clear;
4 close;
5 // Given data
6 g=9.81;// in m/s^2
7 P=1.0332*10^5;// in kN/m^2
8 v='(2.3*10^4/p)^1/1.4';// given expression
9 H= 1/g*(2.3*10^4)^(1/1.4)*integrate('(1/p)^(1/1.4)',
    'p',0,P);// in m
10 disp(H*10^-3,"The value of H in km is : ")
11
12 // Note: There is the calculation error in the book
    in this question , so the answer in the book is
    wrong.

```

Chapter 2

Gas Laws Ideal and Real Gases

Scilab code Exa 2.1 Air pressure in the tyre

```
1 // Exa 2.1
2 clc;
3 clear;
4 close;
5 // Given data
6 p1= 2; // in bar
7 v1= 30; // in litre
8 T1= 27+273; // in K
9 T2= -3+273; // in K
10 v2= v1; // in litre
11 // Gas law  $p_1*v_1/T_1 = p_2*v_2/T_2$ 
12 p2= p1*v1*T2/(T1*v2); // in bar
13 disp(p2,"The air pressure in the tyre in bar is :")
```

Scilab code Exa 2.2 Molar volume of the gas mixture

```
1 // Exa 2.2
2 clc;
```

```

3 clear;
4 close;
5 // Given data
6 p= 12;// in bar
7 p=p*10^5;// in N/m^2
8 v= 25;// in m^3
9 T= 30+273;// in K
10 // Part (a) Mass of each gas
11 //Formula p*v=m*R*T
12 R_U= 8314;// in J/kg-mole K
13 M_N2= 28.016;// in mole
14 M_O2= 32;// in mole
15 M_CO2= 44;// in mole
16 R_N2= R_U/M_N2;// in J/kg K
17 R_O2= R_U/M_O2;// in J/kg K
18 R_CO2= R_U/M_CO2;// in J/kg K
19 m_of_N2= p*v/(R_N2*T);// in kg
20 m_of_O2= p*v/(R_O2*T);// in kg
21 m_of_CO2= p*v/(R_CO2*T);// in kg
22 disp(m_of_N2,"The mass of Nitrogen gas stored in the
    vessel in kg is : ")
23 disp(m_of_O2,"The mass of Oxygen gas stored in the
    vessel in kg is : ")
24 disp(round(m_of_CO2),"The mass of Carbon dioxide gas
    stored in the vessel in kg is : ")
25
26 // Part (b) Molar Volume
27 // Formula v_molar= M*R*T/p= R_U*T/p
28 v_molar= R_U*T/p;// in m^3
29 disp(v_molar,"Molar volume of the gas mixture in m^3
    is : ")
30
31 // Part (c) Average density
32 // rho_avg= total mass/total volume
33 rho_avg= (m_of_N2+m_of_O2+m_of_CO2)/v;// in kg/m^3
34 disp(rho_avg,"Average density of the gas mixture in
    kg/m^3 is : ")

```

Scilab code Exa 2.3 Value of Cp Cv and R

```
1 // Exa 2.3
2 clc;
3 clear;
4 close;
5 // Given data
6 Qp= 1230; // kJ/kg
7 Qv= 795; // kJ/kg
8 t1= 16; // in C
9 t2= 96; // in C
10 R_U= 8.314;
11 delta_T= t2-t1; // in C
12 Cp= Qp/delta_T; // in kJ/kg C
13 disp(Cp,"The value of Cp in kJ/kg C")
14 Cv= Qv/delta_T; // in kJ/kg C
15 disp(Cv,"The value of Cv in kJ/kg C")
16 R= Cp-Cv; // in kJ/kg C
17 disp(R,"The value of R in kJ/kg C")
18 molecular_weight= R_U/R;
19 disp(molecular_weight,"Molecular weight of the gas
    is : ")
```

Scilab code Exa 2.4 Change in internal energy

```
1 // Exa 2.4
2 clc;
3 clear;
4 close;
5 // Given data
6 a= 0.85;
7 b= 0.00004;
```

```

8 c= 5*10^-5;
9 T1= 300;// in K
10 T2= 2300;// in K
11 gama= 1.5;// the ratio of specific heats
12 m=1;// in kg
13 delta_H= m*integrate('a+b*T+c*T^2','T',T1,T2);// in
    kJ
14 disp(delta_H*10^-3,"Change in enthalpy in MJ is : ")
15 // Formula delta_U= integration of m*Cv =
    integration of m*Cp/gama= delta_H/gama
16 delta_U= delta_H/gama;// in kJ
17 disp(delta_U*10^-3,"The change in internal energy in
    MJ is : ")

```

Scilab code Exa 2.5 Pressure exerted by unit mass of the gas

```

1 // Exa 2.5
2 clc;
3 clear;
4 close;
5 // Given data
6 v= 0.9/3;// in m^3/kg
7 v= 2*v;// in m^3/kg mole (as M_hydrogen = 2)
8 T=120+273;// in K
9 R=8314;// in J/kg mole K
10 a=2.51*10^4;// in Nm^4/(kg mole)^2
11 b= 0.0262;
12 // Part (a)
13 p= R*T/v;// in N/m^2
14 p= p*10^-5;// in bar
15 disp(p,"Using perfect gas law the pressure for unit
    mass of hydrogen in bar is : ")
16
17 // Part (b)
18 p= R*T/(v-b)-a/v^2;// N/m^2

```

```
19 p= p*10^-5; // in bar
20 disp(p,"Using Van der waals equation , the pressure
    in bar is : ")
```

Scilab code Exa 2.6 Density of gas

```
1 // Exa 2.6
2 clc;
3 clear;
4 close;
5 // Given data
6 p1= 0.98; // in bar
7 p2= 0.6; // in bar
8 v1= 0.45; // in m^3/kg
9 // Applying Boyle's law
10 v2= p1*v1/p2; // in m^3/kg
11 rho2= 1/v2; // in kg/m^3
12 disp(rho2,"The density of the gas under the changed
    condition in kg/m^3 is : ")
```

Scilab code Exa 2.7 Payload

```
1 // Exa 2.7
2 clc;
3 clear;
4 close;
5 // Given data
6 r=5; // in cm
7 R_U= 8314
8 T= 27+273; // in K
9 V= 4/3*pi*r^3; // volume of balloon in cm^3
10 // atmPressure= 75 cm off mercury = 75/76*1.01325
11 atmPressure= round(75/76*1.01325) ; // in bar
```

```

12 p= atmPressure;// pressure of hydrogen in balloon in
    bar
13 p=p*10^5;// in N/m^2
14 R= R_U/2;// in J/kg K
15 m1= p*V/(R*T);// in kg
16 // The volume of air displaced = the volume of
    balloon , so
17 R=287;
18 T=20+273;// in K
19 m2= p*V/(R*T);// in kg
20 payload= m2-m1;// in kg
21 disp(payload,"Payload that can be lifted along with
    the balloon in kg is : ")

```

Scilab code Exa 2.12 Pressure of the gas

```

1 // Exa 2.12
2 clc;
3 clear;
4 close;
5 // Given data
6 AvogadroNo= 6.023*10^23;
7 n= 5/AvogadroNo;// number of moles
8 v=10^-6;// in m^3
9 T= -270+273;// in K
10 R= 0.287;
11 p= n*R*T/v;// in kPa
12 p= p*10^18;// in aPa
13 disp("The pressure in the space is "+string(p)+" aPa
    ");

```

Scilab code Exa 2.13 Change in enthalpy

```

1 // Exa 2.13
2 clc;
3 clear;
4 close;
5 // Given data
6 T1= 300; // in K
7 T2= 900; // in K
8 m=2; // in kg
9 Cp= '40+600/sqrt(T)+7000/T'; // in kJ/kg mole K
10 delta_H=m* integrate('40-600/sqrt(T)+7000/T', 'T', T1,
    T2); // in kJ/kg mole
11 delta_H= delta_H/17.03; // in kJ/kg
12 disp(delta_H, "Change in enthalpy in kJ/kg is : ")

```

Scilab code Exa 2.14 Molecular weight

```

1 // Exa 2.14
2 clc;
3 clear;
4 close;
5 // Given data
6 m=12; // in kg mol
7 v=723.7; // in m^3
8 T=140; // in C
9 T=T+273; // in K
10 rho= 0.644; // in kg/m^3
11 Ro= 8314; // in J/kg-mole K
12 // rho= m/v, where m in Kg , so rho= m*M/v
13 M= rho*v/m;
14 m= m*M; // in kg
15 disp(M, "Molecular weight is : ")
16
17 // Part (b)
18 R= Ro/M; // in J/kg K
19 disp(R*10^-3, "Gas constant in kJ/kg K")

```

```

20
21 // Part(c)
22 p= m*R*T/v;// in N/m^2
23 p=p*10^-5;// in bar
24 disp(p,"The pressure of the gas in bar is : ")

```

Scilab code Exa 2.15 Load that can be lifted with the air of aerostat

```

1 // Exa 2.15
2 clc;
3 clear;
4 close;
5 // Given data
6 p= 0.98;// in bar
7 p= p*10^5;// in N/m^2
8 v=1000;// in m^3
9 T= 27+273;// in K
10 g= 9.8;
11 M=2;
12 Ro= 8314;// in J/kg-mole K
13 R=Ro/M;// in kg K
14 m= p*v/(R*T);// in kg
15 W= m*g;// in N
16 disp(W,"The load that can be lifted with the air of
    aerostat in N is : ")

```

Scilab code Exa 2.16 Change in enthalpy

```

1 // Exa 2.16
2 clc;
3 clear;
4 close;
5 // Given data

```

```

6 T1= 500; // in K
7 T2= 2000; // in K
8 m=1; // in kg
9 Cp= '11.515-172/sqrt(T)-1530/T'; // in kcal/kg mole K
10 delta_H=m* integrate('11.515-172/sqrt(T)-1530/T', 'T'
    ,T1,T2); // in kcal/kg mole
11 disp(delta_H,"Change in enthalpy in kcal/kg mole is
    : ")

```

Scilab code Exa 2.17 Value of Cv and Cp

```

1 // Exa 2.17
2 clc;
3 clear;
4 close;
5 // Given data
6 u= '196+0.718*t';
7 pv= '0.278*(t+273)';
8 duBydt= 0.718;
9 Cv= duBydt; // in kJ/kg-K
10 h= u+pv;
11 h= '273.351+1.005*t';
12 dhBydt= 1.005; // in kJ/kg-K
13 Cp= dhBydt; // in kJ/kg-K
14 disp(Cv,"The value of Cv in kJ/kg-K is : ")
15 disp(Cp,"The value of Cp in kJ/kg-K is : ")

```

Chapter 3

Zeroth Law of Thermodynamics and Temperature Scales

Scilab code Exa 3.1 Reading

```
1 // Exa 3.1
2 clc;
3 clear;
4 close;
5 // Given data
6 t_c = 303-273; // in C
7 t_f = 9/5* t_c+32; // in F
8 disp(t_f,"When the temperature is 303 K then the
   thermometer reading in F is : ");
9 T_R = 460 + t_f; // R
10 disp(T_R,"The absolute value of the temperature in
   Rankine scale in R is :");
```

Scilab code Exa 3.2 Temperature of fluid


```

1 // Exa 3.2
2 clc;
3 clear;
4 close;
5 // Given data
6 T_K= '273.15+t_C';
7 T_R= '459.67+t_F';
8 // t_C= t_F or T_K-T_R= -186.52      (i)
9 // T_R/T_K = 1.68                    (ii)
10 // From eq (i) and (ii)
11 T_K= -186.52/(1-1.68); // temp. in kelvin in K
12 T_R= 1.68*T_K; // in temp. in rankine in R
13 t_C= T_K-273.15; // in C
14 t_F= T_R-459.67; // in F
15 disp(T_K,"Temperature in kelvin is : ")
16 disp(T_R,"Temperature in R is ")
17 disp(t_C,"Temperature in C is ")
18 disp(t_F,"Temperature in F is ")

```

Scilab code Exa 3.9 Temperature

```

1 // Exa 3.9
2 clc;
3 clear;
4 close;
5 // Given data
6 p0 = 1.86;
7 p100 = 6.81;
8 T1=32;
9 T2= 212;
10 // Relation of T in terms of p for ice point      T1
    = a*log(p0)+b      (i)
11 // Relation of T in terms of p for steam point  T2=
    a*log(p100)+b      (ii)

```

```

12 // From eq(i) and (ii)
13 a= (T2-T1)/log(p100/p0);
14 b= T1-a*log(p0);
15 // The temp at
16 p=2.5;
17 T= a*log(p)+b;// in unit
18 disp(T,"The temperature at p=2.5 in unit is :")

```

Scilab code Exa 3.10 Reading of thermometer

```

1 // Exa 3.10
2 clc;
3 clear;
4 close;
5 // Given data
6 Tp= 'a+b*Tq+lamba*Tq^2';// relation between Tp and
   Tq
7 Tp0=0;//in C (at ice point)
8 Tq0=0;//in C (at ice point)
9 // Putting these values in relation , we get
10 a=0;
11 Tp100=100;//in C ( at steam point)
12 Tq100=100;//in C ( at steam point)
13 // Tp100= b*Tq100+lamba*Tq100^2 (i)
14 Tp=45;// in C (in oil path)
15 Tq=43;// in C (in oil path)
16 // Tp= b*Tq+lamba*Tq^2 (ii)
17 b= (Tp100-Tp*Tq100^2/Tq^2)/(Tq100-Tq100^2/Tq);//
   From eq (i) and (ii)
18 lamda= (Tp-b*Tq)/Tq^2;
19 Tp=20;
20 //lamda*Tq^2+b*Tq-Tp=0
21 P= [lamda b -Tp];
22 Tq= roots(P);// in C
23 disp(Tq,"When P reads 20 C , then the readings of Q

```

```
    in C are")  
24 disp(Tq(2),"The realistic value of Tq in C is : ")  


---


```

Chapter 4

First Law of Thermodynamics

Scilab code Exa 4.1 Work done

```
1 // Exa 4.1
2 clc;
3 clear;
4 close;
5 // Given data
6 p = 1.0; // in MPa
7 p = p * 10^6; // in N per m^2
8 del_v = 1.5; // in m^3 per min
9 del_v = del_v * 60; // in m^3 per h
10 W = p * del_v; // in J
11 W = W * 10^-6; // in MJ
12 disp(W, "Work done by the pump upon the water in MJ")
    ;
```

Scilab code Exa 4.2 Height from which the mass should fall

```
1 // Exa 4.2
2 clc;
```

```

3 clear;
4 close;
5 // Given data
6 // w = 2*g*h
7 g = 9.81;
8 m =(0.2+10/1000)*10^3 ;// in gm
9 s = 1;// in cal/gm C
10 del_T = 2;// in C
11 H = m * s * del_T;// in cal
12 H = H * 10^-3;// kcal
13 J = 4.1868 * 1000;
14 // W= 2*g*h= J*H
15 h = J*H/(2 * g);// in m
16 disp(h,"Height from which the mass should fall in
meter is : ");

```

Scilab code Exa 4.3 Magnitude and direction of third heat transfer

```

1 // Exa 4.3
2 clc;
3 clear;
4 close;
5 // Given data
6 W1 = -25;// in kJ
7 W2 = 45;// in kJ
8 Q1 = 65;// in kJ
9 Q2 = -40;// in kJ
10 // del_U = Q - W and but for a cycle del_U = 0, So
11 // Q = W
12 // Q1 + Q2 +Q3 = W1 +W2
13 Q3 = W1 + W2 - Q1 - Q2;// in kJ
14 disp(Q3,"Third Heat transfer in kJ is ");
15 disp("That is Third Heat transfer is of "+string(abs
(Q3))+ " kJ from the fluid");

```

Scilab code Exa 4.5 External work done

```
1 // Exa 4.5
2 clc;
3 clear;
4 close;
5 // Given data
6 m = 1.5; // in kg
7 T1 = 90; // in C
8 T1 = T1 + 273; // in K
9 T2 = 225; // in C
10 T2 = T2 + 273; // in K
11 C_p = 0.24;
12 C_v = 0.17;
13 Q = (m * C_p * (T2-T1)); // in kcal
14 del_U = (m * C_v * (T2-T1)); // in kcal
15 W = Q - del_U; // in kcal
16 disp(W, "The external work done in kcal is");
```

Scilab code Exa 4.7 Mass of the gas

```
1 //Exa 4.7
2 clc;
3 clear;
4 close;
5 // Given data
6 v1 = 0.5; // in m^3
7 v2 = 0.125; // in m^3
8 p1 = 1.5; // in bar
9 p1 = p1 * 10^5; // in N per m^2
10 p2 = 9; // in bar
11 p2 = p2 * 10^5; // in N per m^2
```

```

12 T1 = 100; // in C
13 T1 = T1 + 273; // in K
14 R = 8.31;
15 // Formula  $p_1*v_1 = n*R*T_1$ 
16 n = p1*v1/(R*T1); // in mole
17 disp(n, "Mass of gas in mole is :");
18 // Part (b)
19 // Formula  $p_1*v_1/T_1 = p_2*v_2/T_2$ 
20 T2 = (p2 * v2 * T1)/(p1 * v1); // in K
21 disp(T2-273, "Temperature at the end of compression
    in C is :");
22 // Part (c)
23 // Formula  $p_1*v_1^n = p_2*v_2^n$ 
24 n1 = log(p2/p1)/log(v1/v2)
25 disp(n1, "Value of index n of compression is :");
26 // Part (d)
27 F = 3;
28 C_v = 1/2*R*F;
29 del_U = (n * C_v * (T2-T1)); // in J
30 disp(del_U*10^-3, "Increase in internal energy of gas
    in kJ is : ");
31 // Part(e)
32 Gamma = 1.67;
33 Q_12 = n*(Gamma-n1)/(1-n1)*R*(T2-T1)/(Gamma-1); // in
    J
34 Q_12 = Q_12 * 10^-3; // in kJ
35 disp(Q_12, "Heat interaction in kJ is : ");
36 if Q_12 < 0 then
37     disp("The -ve sign indicates heat rejection
        during the process")
38 end
39
40 // Note: There is some difference between the answer
    of book and coding . Both the answer is right
    but accurate answer is of coding.
41 //           Because in the book, the taken values
    are approx. and in the coding the values are
    accurate

```

Scilab code Exa 4.8 Law of the process

```
1 //Exa 4.8
2 clc;
3 clear;
4 close;
5 // Given data
6 p1 = 0.01; // in N/mm^2
7 p1 = p1 * 10^3; // in kN/m^2
8 p2 = 50; // in kN/m^2
9 v1 = 5; // in m^3
10 v2 = 1.5; // in m^3
11 Gamma = 1.4;
12 // Formula  $p_1 v_1^n = p_2 v_2^n$ 
13 n = log(p2/p1)/log(v1/v2);
14 disp(n, "Part (a) The value of n is : ")
15 disp("The process followed during air compression is
POLYTROPIC");
16 // Part (b)
17 disp("Part (b) The law of the process is  $p*v^n +$ 
string(n) + " = constant");
18 // Part (c)
19 W = (p1*v1 - p2*v2)/(n-1); // in kNm or (kJ)
20 disp(W, "Part (c) Work done during the process in
kJ is : ");
21 disp("The -ve sign indicates that the work has been
done on the system")
22 // Part (d)
23 Q = ((Gamma - n)/(Gamma - 1) * W); // in kJ
24 disp(Q, "Part (d) Heat transfer during the process
in kJ is : ");
25 disp("The -ve sign indicates that the heat is
rejected from the system")
```

Scilab code Exa 4.9 Change in internal energy

```
1 // Exa 4.9
2 clc;
3 clear;
4 close;
5 // Given data
6 // Relation of specific internal energy of the gas
7 //  $U = 1.5 * p * v - 85$  kJ/kg
8 p1 = 1000; // in kpa
9 p2 = 200; // in pa
10 v1 = 0.20; // in m^3
11 v2 = 1.20; // in m^3
12 m = 1.5; // in kg
13 U1 = 1.5 * p1 * v1 - 85; // kJ/kg
14 U2 = 1.5 * p2 * v2 - 85; // kJ/kg
15 delU = U2 - U1; // in kJ
16 disp(delU, "Change in internal energy in kJ is");
17 // p1 = a + b * v1 (i)
18 // p2 = a + b * v2 (ii)
19 // From eq(i) and (ii)
20 b = (p1 - p2) / (v1 - v2); // in kN/m^2
21 a = p1 - b * v1; // in kN/m^2
22 disp(a, "The value of a in kN/m^2 is ")
23 disp(b, "The value of b in kN/m^2 is ")
24 // Part (c)
25 // Work done = integration of p w.r.t. v and p = a + b
    * v1
26 W = integrate('a + b * v', 'v', v1, v2); // in kJ
27 disp(W, "Work done in kJ is :")
28 // Part (d)
29 Q = delU + W; // in kJ
30 disp(Q, "The net heat transfer in kJ is : ")
```

Scilab code Exa 4.10 Maximum internal energy

```
1 // Exa 4.10
2 clc;
3 clear;
4 close;
5 // Given data
6 a= 1160; // in kN/m^2
7 b= -800; // in kN/m^2
8 v= -a/(2*b)
9 Umax= 1.5*(a*v+b*v^2)-85; // in kJ/kg
10 // For 1.5 kg mass of gas it is
11 Umax= Umax*1.5; // in kJ/kg
12 disp(Umax,"The maximum internal energy of the gas in
    kJ/kg is : ")
```

Scilab code Exa 4.11 Exit velocity of air

```
1 // Exa 4.11
2 clc;
3 clear;
4 close;
5 // Given data
6 T1 = 127; // in C
7 T1 = T1 + 273; // in K
8 R = 287;
9 V1 = 300; // in m/s
10 p1 = 2; // in MPa
11 p2 = 0.5; // in MPa
12 p1 = p1 * 10^6; // in Pa
13 p2 = p2 * 10^6; // in Pa
14 C_P = 1.005*10^3; // in J/ kg-K
```

```

15 Gamma = 1.4;
16 V2 = sqrt(2 * C_P * T1 * {1 - (p2/p1)^((Gamma-1)/Gamma)}
    + V1^2); // in m/s
17 disp(V2, "The exit velocity of air in m/s is : ");
18 m = 600; // in kg/hr
19 m = m / 3600; // in kg/sec
20 v1 = (R * T1)/p1; // in m^3 per kg
21 // m = (A1*V1)/v1 = (A2* V2)/v2
22 A1 = (m * v1)/V1; // in m^2
23 A1 = A1 * 10^6; // in mm^2
24 disp(A1, "Inlet area of the nozzle in square
    milimeter is : ");
25 T2 = T1*(p2/p1)^((Gamma-1)/Gamma); // in K
26 v2 = (R * T2)/(p2); // in m^3/kg
27 A2 = (m * v2)/V2; // in m^2
28 A2 = A2 * 10^6; // in mm^2
29 disp(A2, "Exit area of nozzle in square milimeter is
    : ");

```

Scilab code Exa 4.17 Net heat transfer

```

1 // Exa 4.17
2 clc;
3 clear;
4 close;
5 // Given data
6 W = -1; // in kWh
7 W = W * 10^3 * 3600; // in J
8 del_U = -5000; // in kj
9 del_U = del_U * 10^3; // in J
10 Q = del_U + W; // in J
11 Q = Q * 10^-6; // in MJ
12 disp(Q, "Net heat transfer for the system in MJ is :
    ");

```

Scilab code Exa 4.20 Heat flows into the system

```
1 //Exa 4.20
2 clc;
3 clear;
4 close;
5 // Given data
6 Q_acb = 84; // in kJ
7 W_acb = 32; // in kJ
8 // Formula  $Q_{acb} = \Delta U + W_{acb}$  where  $\Delta U = U_b - U_a$ ;
9  $\Delta U = Q_{acb} - W_{acb}$ ; // in kJ
10 // Part (a) Path a b d
11 W_abd = 10.5; // in kJ
12 Q_abd =  $\Delta U + W_{abd}$ ; // in kJ
13 disp(Q_abd, "Heat flows into the system along the
    path a b d in kJ is : ");
14 // Part (b) curved path b a
15 W_ba = -(21); // in kJ
16 Q_ba =  $-(\Delta U) + W_{ba}$ ; // in kJ
17 disp(abs(Q_ba), "Heat liberated by the system in kJ
    is : ");
18 // Part (c) process a b and d b
19 W_ad = 10.5; // in kJ
20  $\Delta U_1 = 42$ ; // in kJ
21 Q_ad =  $\Delta U_1 + W_{ad}$ ; // in kJ
22 disp(Q_ad, "Heat absorbed in processes a d in kJ is :
    : ");
23 W_db = -(42); // in kJ
24  $\Delta U_2 = 52$ ; // in kJ
25 Q_bd =  $\Delta U_2 + W_{db}$ ; // in kJ
26 disp(Q_bd, "Heat absorbed in processes b d in kJ is :
    ");
27 W_db = 0;
```

```

28 W_abd = W_ad + W_db; // in kJ
29 disp(W_abd,"Heat absorbed in processes in a d and d
    b in kJ is : ");

```

Scilab code Exa 4.21 Net work

```

1 //Exa 4.21
2 clc;
3 clear;
4 close;
5 // Given data
6 v1 = 5; // in m^3
7 p1 = 2; // in bar
8 p2 = 6; // in bar
9 p3 = 2; // in bar
10 p1 = p1 * 10^5; // in N/m^2
11 p2 = p2 * 10^5; // in N/m^2
12 p3 = p3 * 10^5; // in N/m^2
13 n = 1.3;
14 v2 = v1 * ((p1/p2)^(1/1.3)); // in m^3
15 W1_2 = ((p2 * v2) - (p1 * v1))/(1-n); // in J
16 Gamma = 1.4;
17 v3 = v2 * ((p2/p3)^(1/Gamma)); // in m^3
18 W2_3 = ((p3 * v3) - (p2 * v2))/(1-Gamma); // in J
19 W_net = W1_2 + W2_3; // in J
20 W_net = W_net * 10^-3; // in kJ
21 disp(W_net,"net work done in kJ is : ");

```

Chapter 5

First Law of Thermodynamics

Scilab code Exa 5.1 Mass flow rate of air

```
1 // Exa 5.1
2 clc;
3 clear;
4 close;
5 // Given data
6 v1_total = 7; // in m^3/min
7 v_s1 = 0.35; // in m^3/kg
8 v_s2 = 0.12; // in m^3/kg
9 p1 = 1; // in bar
10 p1 = p1 * 10^5; // in N/m^2
11 p2 = 6; // in bar
12 p2 = p2 * 10^5; // in N/m^2
13 D1 = 110; // in mm
14 D1 = D1 * 10^-3; // in m
15 D2 = 65; // in mm
16 D2 = D2 * 10^-3; // in m
17 Af1 = %pi/4*D1^2; // in m^2
18 Af2 = %pi/4*D2^2; // in m^2
19 // v1_total = m1 * v_s1
20 m1 = v1_total / v_s1; // in kg/min
21 disp(m1, "The mass flow rate of air in kg/min is :");
```

```

22 m2 = m1; // in kg/min
23 v2_total = m2 * v_s2; // in m^3/min
24 del_W_flow = (p2 * v2_total) - (p1 * v1_total); // in
    J/min
25 disp(del_W_flow*10^-3, "The change in the work flow
    in kJ/min is : ");
26 v_f1 = v1_total/Af1; // in m/min
27 v_f2 = v2_total /Af2; //in m/min
28 del_v = v_f2 - v_f1; // in m/min
29 disp(del_v, "Change in velocity of the air flow in m/
    min is :");

```

Scilab code Exa 5.2 Rate of heat transfer

```

1 //Exa 5.2
2 clc;
3 clear;
4 close;
5 // Given data
6 m = 2; // in kg per min
7 m = m / 60; // in kg per sec
8 W = 20; // in kW
9 h1 = 1400; // in kJ/kg
10 h2 = 1300; // in kJ/kg
11 Q = (m * (h2 - h1)) + W; // in kJ/s
12 disp(Q, "Rate of heat transfer to the water jacket in
    kJ/sec");

```

Scilab code Exa 5.3 Power output of the turbine

```

1 // Exa 5.3
2 clc;
3 clear;

```

```

4 close;
5 // Given data
6 g= 9.81;
7 p1 = 3;// in Mpa
8 p2 = 10;// in kPa
9 T1 = 350;// in C
10 T1 = T1 + 273;// in K
11 m = 1;// in kg per sec
12 v1 = 50;// in m per sec
13 v2 = 120;// in m per sec
14 z1 = 2;// in m
15 z2 = 5;// in m
16 C_p = 1.005;// in kJ per sec
17 Q = 5;// in kJ per sec
18 Q = -(Q) * 10^3;// in J per sec
19 T2 = (p2 * T1)/p1;// in K
20 del_h = C_p * (T2-T1);// in kJ
21 del_h = del_h * 10^3;// in J
22 t = m * ( del_h +(v2^2-v1^2)/2 + (g * (z2 - z1)));//
    t is variable taken for calculation
23 W_s = Q - t;// in J per sec
24 W_s = W_s * 10^-6;// in MW
25 disp(W_s,"The power output of the turbine in MW");
26 // If kinetic and potential energy are ignored then
27 W_s2 = Q -(m * del_h);// in J per sec
28 W_s2 = W_s2 * 10^-6;// in MW
29 errorIntroduced= (abs(W_s)-abs(W_s2))/abs(W_s)*100;
    // in %
30 disp(errorIntroduced,"Total error introduced in % is
    :");

```

Scilab code Exa 5.4 Quantity of water circulated

```

1 //Exa 5.4
2 clc;

```



```

3 clear;
4 close;
5 //Given data
6 h1 = 246.6; // in kJ/kg
7 h2 = 198.55; // in kJ/kg
8 W = 0;
9 g= 9.8;
10 Q= -(105000); // in kJ per hr
11 // m * (h1 + ((v1*^2)/(2*1000)) + ((g * z1)/1000)) +
    Q = m * (h2 + ((v2^2)/(2*1000)) + ((g * z2)
    /1000)) + W
12 // v1 and v2 is change in velocity is neglected and
    z2 = z1 + 10
13 m = Q/( (h2-h1) + ((g * 10)/1000) ); // kg per hr
14 disp(m,"Quantity of water circulated through the
    pipe in kg/hr is");

```

Scilab code Exa 5.5 Power of motor required

```

1 //Exa 5.5
2 clc;
3 clear;
4 close;
5 //Given data
6 m=15; // in kg/min
7 m= m/60; // in kg/sec
8 H1= 5; // in kJ/kg
9 H1= H1*10^3; // in J/kg
10 H2= 173; // in kJ/kg
11 H2= H2*10^3; // in J/kg
12 V1= 5; // in m/s
13 V2= 7.5; // in m/s
14 Q= 760; // in kJ/min
15 Q= Q*10^3/60; // in J/s
16 // Formula (H1+V1^2/2)+(-Q)= (H2+V2^2/2)+W

```

```

17 W= (H1+V1^2/2)+(-Q)-(H2+V2^2/2); // in W/kg
18 W= W*10^-3; // in kW/kg
19 // The work done will be
20 W= m*W; // in kW
21 P= abs(W); // in kW
22 disp(P,"Power of the motor required to drive the
      compressor in kW is : ")
23 // Part (b)
24 v1= 0.5; // in m^3/kg
25 v2= 0.15; // in m^3/kg
26 // A1/A2= rho2*V2/(rho1*V1) = v1*V2/(v2*V1)
27 ratio0FA1andA2= v1*V2/(v2*V1);
28 radio0Fd1andd2= sqrt(ratio0FA1andA2);
29 disp(ratio0Fd1andd2,"Ratio of inlet pipe diameter to
      outlet pipe diameter is : ")

```

Chapter 6

Second Law of Thermodynamics

Scilab code Exa 6.1 Temperature of the source and the sink

```
1 //Exa 6.1
2 clc;
3 clear;
4 close;
5 //Given data
6 // In first case  $(T_1 - T_2) / T_1 = 1/6$  or
   T1= 1.2*T2 (i)
7 // In second case  $(T_1 - (T_2 - 62)) / T_1 = 2/6$  or  $2 * T_1$ 
    $-3 * (T_2 - 62) = 0$  (ii)
8 // From eq (i) and (ii)
9 T2= 186/0.6; // in K
10 T1= 1.2*T2; // in K
11 disp(T2-273, "Temperature of the source in C is : ")
   )
12 disp(T1-273, "Temperature of the sink in C is : ")
```

Scilab code Exa 6.2 Minimum power required

```
1 // Exa 6.2
2 clc;
3 clear;
4 close;
5 // Given data
6 T1 = 25; // in C
7 T2 = 1; // in C
8 T1 = T1 + 273; // in K
9 T2 = T2 + 273; // in K
10 HT= 2; // heat transfer across the wall and the roof
    in MJ/hr
11 HT= HT*10^6; // in J/hr
12 Q = HT* (T1-T2); // in J/hr
13 COP_heat = T1/(T1-T2);
14 W_net = Q/COP_heat; // in J/hr
15 disp(W_net*10^-3/3600, "Power rquired for operating
    the pump in kW");
16 // Part (b)
17 T2= 25; // in C
18 T2=T2+273; // in K
19 // COP= T2/(T1-T2) (i)
20 // COP= HT*(T1-T2)/W_net (ii)
21 // From (i) and (ii)
22 T1= sqrt(W_net*T2/HT)+T2; // in K
23 T1= T1-273; // in C
24 disp(T1, "The value of T1 in C is : ")
```

Scilab code Exa 6.3 Ratio of heat transfer to circulating water to the engine

```
1 //Exa 6.3
2 clc;
3 clear;
```

```

4  close;
5  //Given data
6  heatEngineEffi= 32/100;// heat engine efficiency
7  COP= 5;// COP of heat pump
8  // heat engine efficiency = Wnet/Q1 = (Q1-Q2)/Q1
9  Q1byWnet= 1/heatEngineEffi;
10 Q2byWnet= (1-heatEngineEffi)*Q1byWnet;
11 // COP = Q4/Wnet = Q4/(Q4-Q3)
12 Q4byWnet= COP;
13 ratio= (Q2byWnet+Q4byWnet)/Q1byWnet;// ratio of heat
      transferred to the circulating water to heat
      trasferred to the engine
14 disp(ratio,"Ratio of heat trasferred to the
      circulating water to heat trasferred to the
      engine is : ")

```

Scilab code Exa 6.4 Claim of inventor is true or not

```

1  //Exa 6.4
2  clc;
3  clear;
4  close;
5  //Given data
6  Q = 88;// in MJ
7  Q=Q*10^3;// in kJ
8  T1 = 190;// in C
9  T1 = T1 + 273;// in K
10 T3 = -15;// in C
11 T3 = T3 + 273;// in K
12 Eta_carnot = (T1 - T3)/T1;
13 Wnet= Eta_carnot * Q;// in kJ
14 CarnotPower= Wnet/3600;// in kWh
15 disp(CarnotPower,"The value of Carnot Power in kWh
      is : ")
16 disp("As the actual power produced by the invented

```

```

    engine is more than the Carnot Power, ");
17 disp("so inverter claim is ")
18 disp(" not true")

```

Scilab code Exa 6.5 Minimum power required

```

1 //Exa 6.5
2 clc;
3 clear;
4 close;
5 // Given data
6 T1 = 24; // in C
7 T1 = T1 + 273; // in K
8 T2 = 2; // in C
9 T2 = T2 + 273; // in K
10 Q = 100; //in MJ/h
11 Q = Q * 10^3; //in kJ/h
12 COP_heatPump = T1/(T1-T2);
13 W = Q/COP_heatPump; //in kJ/h
14 W = W/3600; // in kW
15 disp(W,"The theoretical minimum power required to
    drive the heat pump in kW is : ")
16 COP_refrigerator = T2/(T1-T2);
17 W = Q/COP_refrigerator; // in kJ/h
18 W = W/3600; // in kW
19 disp(W,"The theoretical power required to drive the
    heat pump when it is used as a refrigerator in kW
    is : ");

```

Scilab code Exa 6.6 Reversible or irreversible cycle

```

1 //Exa 6.6
2 clc;

```

```

3 clear;
4 close;
5 //Given data
6 Q1= 278;// in kJ/s
7 T1= 283+273;// in K
8 T2= 50+273;// in K
9 // Let integrate of delta Q by T is V
10 disp("Part (a)")
11 Q2= 208;// in kJ/s
12 // By Clausius inequality
13 V= Q1/T1-Q2/T2;
14 if V<0 then
15     disp("The cycle is irreversible")
16 else
17     if V>0 then
18         disp("Reversible or irreversible cycle is
19             not possible and the result is impossible
20             ")
21     else
22         disp("The cycle is reversible")
23     end
24 end
25 disp("Part (b)")
26 Q2= 139;// in kJ/s
27 V= Q1/T1-Q2/T2;
28 if V<0 then
29     disp("The cycle is irreversible")
30 else
31     if V>0 then
32         disp("Reversible or irreversible cycle is
33             not possible and the result is impossible
34             ")
35     else
36         disp("The cycle is reversible")
37     end
38 end
39 disp("Part (c)")
40 Q2= 161.5;// in kJ/s

```

```

37 V= Q1/T1-Q2/T2;
38 if V<0 then
39     disp("The cycle is irreversible")
40 else
41     if V>0 then
42         disp("Reversible or irreversible cycle is
                not possible and the result is impossible
                ")
43     else
44         disp("The cycle is reversible")
45     end
46 end

```

Scilab code Exa 6.16 Heat rejected

```

1 //Exa 6.16
2 clc;
3 clear;
4 close;
5 // Given data
6 Wnet_compressor= 3;// in kW
7 Wnet_compressor=Wnet_compressor*3600;// in kJ/h
8 Qabsorbed= 50;// in MJ/h
9 Qabsorbed=Qabsorbed*10^3;// in kJ/h
10 T1 = 46+273;// in K
11 T2 = 1+273;// in K
12 Qrejected= Wnet_compressor+Qabsorbed;// in kJ/h
13 disp(Qrejected*10^-3,"The heat rejected in MJ/h is :
    ")
14 I= -(-Qrejected/T1+Qabsorbed/T2);// in kJ/h
15 disp(I,"Irreversibility in kJ/h is : ")

```

Scilab code Exa 6.17 Entropy generated


```

1 //Exa 6.17
2 clc;
3 clear;
4 close;
5 // Given data
6 T1 = 12; // in C
7 T2 = 92; // in C
8 T1 = T1 + 273; // in K
9 T2 = T2 + 273; // in K
10 del_T = T2 - T1; // in K
11 m = 20; // in kg
12 C_v = 4.187;
13 s = 1;
14 Q = m * s * del_T; // in cal
15 Q = Q * 4.18; // in J
16 H = 2; // heat given by the heater in kw
17 H = H * 10^3; // in J/sec
18 t = Q/H; //time taken by the heater to raise the temp
    . in sec
19 disp(t, "Time taken by the heater to raise the
    temperature in sec is");
20 del_phi = m * C_v * log(T2/T1); // in kJ/K
21 disp(del_phi, "Entropy generated during the process
    in kJ/K");

```

Scilab code Exa 6.18 Reversible irreversible or carnot cycle

```

1 // Exa 6.18
2 clc;
3 clear;
4 close;
5 // Given data
6 Q1 = 1000; // in kW
7 Q2 = 492; // in kW
8 T1 = 285; // in C

```

```

 9 T1 = T1 + 273; // in K
10 T2 = 5; // in C
11 T2 = T2 + 273; // in K
12 Eta_carnot = (T1-T2)/T1*100; // in percentage
13 disp(Eta_carnot,"Carnot efficiency in % is : ")
14 Eta_heat = (Q1 - Q2)/Q1*100; // in percentage
15 disp(Eta_heat,"Efficiency of the heat engine in % is
      : ")
16 if Eta_heat>Eta_carnot then
17     disp("As the efficiency of heat engine cannot be
          more than Carnot efficiency , Hence engine
          cannot execute irreversible cycle.So engine
          will execute Carnot Cycle which is a
          reversible cycle too")
18 end

```

Scilab code Exa 6.19 Output of the engine

```

1 // Exa 6.19
2 clc;
3 clear;
4 close;
5 // Given data
6 n = 1080; // in cycle/min
7 Q_s = 57; // in J/cycle
8 T1 = 12; // in C
9 T1 = T1 + 273; // in K
10 T2 = 2; // in C
11 T2 = T2 + 273; // in K
12 //  $1 - (Q_r/Q_s) = 1 - (T2/T1)$ 
13 Q_r = (T2/T1)*Q_s; // in J/cycle
14 W = Q_s - Q_r; // in J/cycle
15 P_o = W * n; // in J/min
16 P_o = P_o/60; // in W
17 disp(P_o,"The output of the engine in watt is");

```

Scilab code Exa 6.20 Minimum power required

```
1 // Exa 6.20
2 clc;
3 clear;
4 close;
5 // Given data
6 Q2 = 10^5; // in kJ/hr
7 T1 = -3; // in C
8 T1 = T1 + 273; // in K
9 T2 = 22; // in C
10 T2 = T2 + 273; // in K
11 COP_heat = 1/(1-T1/T2);
12 W = Q2/COP_heat; // in kJ/hr
13 W = W/3600; // in kW
14 disp(W, "Minimum power required in kW is");
```

Scilab code Exa 6.21 Engine efficiency

```
1 //Exa 6.21
2 clc;
3 clear;
4 close;
5 // Given data
6 T_A= 927+273; // in K
7 T_B= 127+273; // in K
8 T_C= T_B; // in K
9 //  $Q_A = Q_B + Q_C + W = 2*Q_B + W$  (since  $Q_B = Q_C$ ) (i)
10 //  $Q_A/T_A = Q_B/T_B + Q_C/T_C$  or
11 //  $Q_A = 2*Q_B*T_A/T_B$  (ii)
12 // From eq (i) and (ii)  $W = 2*Q_B*(T_A/T_B - 1)$  (iii)
   )
```

```

13 // Dividing (iii) by (ii)
14 WbyQ_A= (T_A/T_B-1)/(T_A/T_B);
15 disp(WbyQ_A*100,"The engine efficiency in % is : ")

```

Scilab code Exa 6.22 Heat rejected

```

1 //Exa 6.22
2 clc;
3 clear;
4 close;
5 // Given data
6 T_A= 700; // in K
7 T_B= 600; // in K
8 T_C= 500; // in K
9 Q_A= 1200; // in kJ
10 // Q_B+Q_C= Q_A-200 (i)
11 // Q_A/T_A = Q_B/T_B+Q_C/T_C (ii)
12 // From eq(i) and (ii)
13 Q_B= (Q_A*(1/T_B-1/T_A)-200/T_B)/(1/T_B-1/T_C); // in
    kJ
14 Q_C= Q_A-Q_B-200; // in kJ
15 disp(Q_B,"The heat rejected at B in kJ is : ")
16 disp(Q_C,"The heat rejected at C in kJ is : ")

```

Scilab code Exa 6.23 Intermediate temperature

```

1 //Exa 6.23
2 clc;
3 clear;
4 close;
5 // Given data
6 T1= 180+273; // in K
7 T2= 20+273; // in K

```

```

8 // WA/Q1= 1-T3/T1      (i)
9 // WB/QB= 1-T2/T3      (ii)
10 // WA= WB                (iii)
11 // Q1= QB+WA            (iv)
12 // From eq(i),(ii),(iii) and (iv)
13 T3= (T1+T2)/2; // in K
14 disp(T3-273,"The intermediate temperature in C is
: ")

```

Scilab code Exa 6.24 Least power necessary to pump

```

1 //Exa 6.24
2 clc;
3 clear;
4 close;
5 // Given data
6 Q2 = 1.75; // in kJ/sec
7 T1 = -15; // in C
8 T1 = T1 + 273; // in K
9 T2 = 30; // in C
10 T2 = T2 + 273; // in K
11 del_T = T2 - T1; // in K
12 // Q2/Wnet = T2/(del_T)
13 Wnet = Q2 * del_T/T1; // in kW
14 disp(Wnet,"Least power required in kW is");

```

Chapter 7

Entropy

Scilab code Exa 7.2 Change in entropy of air

```
1 //Exa 7.2
2 clc;
3 clear;
4 close;
5 // Given data
6 v1 = 0.05; // in m^3
7 v2 = 8 * v1; // in m^3
8 T1 = 280; // in C
9 T1 = T1 + 273; // in K
10 T2 = 25; // in C
11 T2 = T2 + 273; // in K
12 p1 = 8; // in bar
13 C_p = 1.005; // in kJ/kgK
14 C_v = 0.712; // in kJ/kgK
15 R = C_p - C_v; // in kJ/kgK
16 del_phi = (R * ( log(v2/v1) ) ) + (C_v * (log(T2/T1))
17 ); // in kJ/kgK
18 disp(del_phi, "The change in entropy of air during
19 the process in kJ/kgKis");
```

Scilab code Exa 7.3 Overall change in entropy

```
1 // Exa 7.3
2 clc;
3 clear;
4 close;
5 // Given data
6 m = 5; // in kg
7 T1 = 50; // in C
8 T1 = T1 + 273; // in K
9 T2 = 250; // in C
10 T2 = T2 + 273; // in K
11 C_p = 1.0;
12 C_v = 0.72;
13 T3 = 50; // in C
14 T3 = T3 + 273; // in K
15 del_phi = m * C_p * (log(T2/T1)); // in kJ/ K (this
    is increase in entropy)
16 del_phi1 = m * C_v * (log(T3/T2)); // in kJ/K (this
    is decrease in entropy)
17 phi_net = del_phi - abs(del_phi1); // in kJ/K
18 disp(phi_net, "The net change in entropy in kJ/K is"
    );
```

Scilab code Exa 7.6 Entropy generated during the process

```
1 // Exa 7.6
2 clc;
3 clear;
4 close;
5 // Given data
6 Q1 = 1600; // in kJ
```

```

7 Q2 = 1600; // in kJ
8 T1 = 800; // in K
9 T2 = 127; // in C
10 T2 = T2 + 273; // in K
11 d1_phi = Q1/T1; // in kJ per K
12 d2_phi = Q2/T2; // in kJ per K
13 net_phi = d2_phi - d1_phi; // in kJ per K
14 disp(net_phi, "Total entropy generated during the
    process in kJ/K is : ");

```

Scilab code Exa 7.8 The flow of air

```

1 // Exa 7.8
2 clc;
3 clear;
4 close;
5 // Given data
6 T_A= 50+273; // in K
7 T_B= 13+273; // in K
8 P_A= 130; // in kPa
9 P_B= 100; // in kPa
10 Cp= 1.005; // in kJ/kg-K
11 pvByT= 0.287; // p in kPa, v in m^3/kg, T in K
12 del_S_system= Cp*log(T_B/T_A)-pvByT*log(P_B/P_A); //
    in kJ/kg-K
13 del_S_surrounding=0;
14 del_S_universe= del_S_system+del_S_surrounding; // in
    kJ/kg-K
15 disp(del_S_universe, "The change in entropy in kJ/kg-
    K is : ")
16 disp("But a negative change in entropy is not
    possible,");
17 disp("hence the flow of air must be from B to A")

```

Scilab code Exa 7.9 Change in entropy

```
1 // Exa 7.9
2 clc;
3 clear;
4 close;
5 // Given data
6 m = 5; // in kg
7 s = 4.18;
8 T1 = 0; // in C
9 T2 = 20; // in C
10 dt = T2 - T1; // in C
11 Q = m * s * dt; // in kJ
12 L = 335; // in kJ/kg
13 // Q = m_i * l
14 m_i = Q/L; // in kg
15 T1 = T1 + 273; // in K
16 T2 = T2 + 273; // in K
17 del_S = ((m_i * L)/T1) - (m * s * (log(T1/T2))); //
    in kJ per K
18 disp(del_S, "Change in entropy of the adiabatic in
    kJ/K is");
```

Scilab code Exa 7.11 Net heat transfer and overall change in entropy

```
1 //Exa 7.11
2 clc;
3 clear;
4 close;
5 // Given data
6 p1 = 1 * 10^5; // in N/m^2
7 C_p = 1.005; // in kJ/kg k
```

```
8 R = 287; // in j/kg k
9 T1 = 290; // in K
10 T2 = 580; // in K
11 v1 = 1; // in m^3
12 m = (p1 * v1)/(R * T1); // in kg
13 Q = m * R * (T2-T1); // in J
14 Q = Q * 10^-3; // in kJ
15 del_phi = m * C_p * (log(T2/T1)); // in kJ per K
16 R = R * 10^-3; // in kJ/kg K
17 C_v = C_p - R; // in kJ/kg k
18 del1_phi = m * C_v * (log(T1/T2)); // in kJ/K
19 net_phi = del_phi + del1_phi; // in kJ/K
20 disp(net_phi, "Over all change in entropy in kJ/K");
```

Chapter 8

Availability and Irreversibility

Scilab code Exa 8.1 Availability and unavailability of heat

```
1 //Exa 8.1
2 clc;
3 clear;
4 close;
5 // Given data
6 Q = 16; // in MJ
7 Q = Q * 10^3; // in kJ
8 T_H = 227; // in C
9 T_H = T_H + 273; // in K
10 T_L = 15; // in C
11 T_L = T_L + 273; // in K
12 del_S = Q/T_H; // in kJ/K
13 A = Q - (T_L * del_S); // in kJ
14 disp(A,"The available part of heat in kJ is ");
15 U_P_ofHeat = T_L * del_S; // unavailable part of heat
    in kJ
16 disp(U_P_ofHeat,"The unavailable part of heat in kJ
    is :");
```

Scilab code Exa 8.2 Availability and unavailability of system

```
1 //Exa 8.2
2 clc;
3 clear;
4 close;
5 // Given data
6 Q = 12000; // in kJ
7 T_H = 600; // in K
8 T_L = 300; // in K
9 dS = Q / T_H; //in kJ/K
10 A = Q - (T_L * dS); //available work in kJ
11 disp(A, "Available work is in kJ");
12 UA = T_L * dS; //unavailable work in kJ
13 disp(UA, "Anavailable work is in kJ");
```

Scilab code Exa 8.3 Available and unavailable energy

```
1 // Exa 8.3
2 clc;
3 clear;
4 close;
5 // Given data
6 m = 800; // in kg
7 C_p = 0.5; // in kJ/kg K
8 T2 = 500; // in K
9 T1 = 1250; // in K
10 T_o = 300; // in K
11 del_t = T1 - T2; // in K
12 Q = m * C_p * del_t; // in kJ
13 dS = abs(m * C_p * log(T2/T1)); // in kJ/K
14 availableEnergy = Q - (T_o * dS); //in kJ
15 disp(round(availableEnergy*10^-3), "Available energy
    in MJ is :");
16 unavailableEnergy = T_o * dS; // UA stands for
```

```

    unavailable energy in kJ
17 disp(round(unavailableEnergy*10^-3)," Unavailable
    energy in MJ is :");

```

Scilab code Exa 8.4 Availability per kg of steam entering and leaving the turbine

```

1 //Exa 8.4
2 clc;
3 clear;
4 close;
5 // Given data
6 h_i = 726.1;
7 h_o = 25.03;
8 T_o = 298; // in K
9 s_i = 1.582;
10 s_o = 0.087;
11 h2 = 669;
12 s2 = 1.677;
13 h3 = 52.17 + (0.9 * 567.7);
14 s3 = 0.1748 + (0.9 * 1.7448);
15 sai_i = (h_i - h_o) - (T_o * (s_i - s_o)); // in kcl/
    kg
16 disp(sai_i,"The availablility per kg of steam
    entering in kcl/kg is :");
17 sai_e = (0.25 * ((h2 - h_o) - (T_o * (s2 - s_o)))) +
    (0.75 * ((h3 - h_o) - (T_o * (s3 - s_o)))) ; //
    in kcl/kg
18 disp(sai_e,"The availablility per kg of steam
    leaving in kcl/kg is :");
19 w_rev = sai_i - sai_e; // in kcl/kg
20 disp(w_rev,"reveseble work per kg of steam in kcl/kg
    ");
21
22 // Note: There is calculation error in evaluating

```

the value of availability per kg of steam leaving
in kcal/kg . so the answer in the book is wrong
and coding is right.

Scilab code Exa 8.5 Irreversibility

```
1 // Exa 8.5
2 clc;
3 clear;
4 close;
5 // Given data
6 T_o = 298; // in K
7 m2 = 25000;
8 s2 = 16775;
9 m3 = 75000;
10 s3 = 17448;
11 m1 = 1000000;
12 s1 = 1582;
13 Q = -16; // in MJ
14 Q = Q * 10^3; // in kJ
15 I = (T_o * ((m2 * s2) + (m3 * s3) - (m1 * s1))) - Q;
    // in cal/hr
16 I=I*10^-3; // in kcal/hr
17 disp(I,"The irreversibility in kcal/hr");
18
19 // Note: There is calculation error in evaluating
    the value of the irreversibility in kcal/hr. so
    the answer in the book is wrong and coding is
    right.
```

Scilab code Exa 8.6 Availability per kg of steam

```
1 // Exa 8.6
```

```

2  clc;
3  clear;
4  close;
5  // Given data
6  h_i = 749.2;
7  h_o = 25.03;
8  T_o = 298; // in K
9  s_i = 1.6202;
10 s_o = 0.0877;
11 phi_i = (h_i - h_o) - (T_o * (s_i - s_o)); // kcal/kg
12 disp(phi_i, "The availablility before adiabatic
    throttling in kcal/kg is : ");
13 h_e = 749.2;
14 s_e = 1.6936;
15 phi_e = (h_e - h_o) - (T_o * (s_e - s_o)); // in kcal
    /kg
16 disp(phi_e, "The availablility before adiabatic
    throttling in kcal/kg is : ");
17 Wrev = phi_i - phi_e; // in kcal/kg
18 disp(Wrev, "Reversible work in kcal/kg is : ");
19 Wactual = 0;
20 i = Wrev - Wactual; // in kcal/kg
21 disp(i, "Irreversibility per kg of steam in kcal/kg
    is : ");

```

Scilab code Exa 8.7 Lost work

```

1  //Exa 8.7
2  clc;
3  clear;
4  close;
5  // Given data
6  // del_W = T * ds - del_Q
7  T = 600; // in K
8  p_i = 7; // kgf/cm^2

```

```
9 p_e = 1.5; //kgf/cm^2
10 T_o = 298; // in K
11 R = 29.27/427;
12 del_W_lost = T * ( R *log(p_i/p_e)); // in kcal/kg
13 disp(del_W_lost,"Lost work in kcal/kg is");
14 i = T_o * (R * (log(p_i/p_e))); // in kcal/kg
15 disp(i,"Irreversibility per kg of air flow in kcal/
    kg is");
```

Chapter 9

Properties of Steam and Thermodynamic Cycles

Scilab code Exa 9.1 Specific volume enthalpy latent heat and entropy

```
1 // Exa 9.1
2 clc;
3 clear;
4 close;
5 // Given data
6 disp("Part (i) : For dry saturated steam at 17.8 bar
      ")
7 p= 17.8;// in bar
8 p1= 17.5;// in bar
9 p2= 18.0;// in bar
10 Vs1= 0.1135;// in litre/kg
11 Vs2= 0.1104;// in litre/kg
12 Hs1= 2796.1;// in kJ/kg
13 Hs2= 2796.4;// in kJ/kg
14 L1= 1918;// in kJ/kg
15 L2= 1912;// in kJ/kg
16 phi_s1= 6.389;// in kJ/kg K
17 phi_s2= 6.379;// in kJ/kg K
18 Vs= Vs1-(Vs2-Vs1)/(p2-p1)*(p-p1);// in litre/kg
```

```

19 Hs= Hs1+(Hs2-Hs1)/(p2-p1)*(p-p1); // in kJ/kg
20 L= L1- (L1-L2)/(p2-p1)*(p-p1); // in kJ/kg
21 phi_s= phi_s1- (phi_s1-phi_s2)/(p2-p1)*(p-p1); // in
    kJ/kg K
22 disp("Part (i) : For dry saturated steam at 17.8 bar
    ")
23 disp(Vs,"The specific volume in litre/kg is : ");
24 disp(Hs,"The enthalpy in kJ/kg is : ");
25 disp(L,"The latent heat in kJ/kg is : ");
26 disp(phi_s,"The entropy in kJ/kg K")
27 disp("Part (ii) : For superheated steam at 16 bar
    and 340 C")
28 T= 340; // in K
29 T1= 300; // in K
30 T2= 350; // in K
31 Vsup1= 0.1585; // in m^3/kg
32 Vsup2= 0.1743; // in m^3/kg
33 Hsup1= 3030; // in kJ/kg
34 Hsup2= 3142; // in kJ/kg
35 phi_sup1= 6.877; // in kJ/kg K
36 phi_sup2= 7.063; // in kJ/kg K
37 Vsup= Vsup1+(Vsup2-Vsup1)/(T2-T1)*(T-T1); // in m^3/
    kg
38 Hsup= Hsup1+(Hsup2-Hsup1)/(T2-T1)*(T-T1); // in kJ/kg
39 phi_sup= phi_sup1+(phi_sup2-phi_sup1)/(T2-T1)*(T-T1)
    ; // in kJ/kg
40 disp(Vsup,"The specific volume in m^3/kg is : ");
41 disp(Hsup,"The enthalpy in kJ/kg is : ");
42 disp(phi_sup,"The entropy in kJ/kg K is : ")

```

Scilab code Exa 9.2 Condition of steam

```

1 // Exa 9.2
2 clc;
3 clear;

```

```

4 close;
5 // Given data
6 h_sen = 798.43; // in kJ/kg
7 L = 1984.3; // in kJ/kg
8 H_total_wet = 2665.7;
9 // H_total_wet= h_sen+x*L
10 x = (H_total_wet - h_sen)/L;
11 disp(x,"The value of x is :");
12 // Part (b)
13 h_total_sup= 2961; // in kJ/kg
14 Cps= 2.112; // in kJ/kg
15 H_total_dry= 2782.7; // in kJ/kg
16 // Let deltaT= T_sup-T_sat
17 // h_total_sup = h_sen+L+h_sup = H_total_dry +Cps*
    deltaT
18 deltaT= (h_total_sup-H_total_dry)/Cps; // in C
19 disp(deltaT,"Degree of superheat in C is :")

```

Scilab code Exa 9.3 Change in enthalpy and entropy

```

1 // Exa 9.3
2 clc;
3 clear;
4 close;
5 // Given data
6 H2 = 3055; // in kj per kg
7 H3 = 2550; // in kj per kg
8 fie_1 = 7.15; // kj per kg k
9 fie_2 = 7.57; // kj per kg k
10 d_fie= fie_2 - fie_1; // in kj per kg k
11 disp(d_fie,"Change in entropy during throttling
    process in kJ/kg-K is :");
12 dH = H2 - H3; // in kj per kg
13 disp(dH,"Change in enthalpy during isentropic
    process in kJ/kg is : ");

```

Scilab code Exa 9.4 Quantity of heat

```
1 // Exa 9.4
2 clc;
3 clear;
4 close;
5 // Given data
6 H_w = 670.4; // in kJ/kg
7 L = 2085; // kJ per kg
8 T_sat = 158.8; // in degree c
9 m = 4; // in kg
10 x = 0.5;
11 h_sen = 670.4; // in kJ/kg
12 H_totalwet = m * ( h_sen + (x *L)); // in kJ
13 x1 = 0.95
14 H_totalwet1 = m *( h_sen + (x1 *L)); // in kJ
15 Q1 = H_totalwet1 - H_totalwet; // in kJ
16 disp(Q1,"Part (i) The quantity of heat in case first
    in kJ is : ");
17 // Part (b)
18 x2 = 1;
19 H_totaldry = m *( h_sen + (x2 *L)); // in kJ
20 Q2 = H_totaldry - H_totalwet; // in kJ
21 disp(Q2,"Part (ii) The quantity of heat in case
    second in kJ is : ");
22 // Part (c)
23 H_totalsup = 3062.3; // in kJ per kg
24 H_totalsup = m * H_totalsup; // in kJ
25 Q3 = H_totalsup - H_totalwet; // in kJ
26 disp(Q3,"Part (iii) The quantity of heat in case
    third in kJ is : ");
27 // Part (d)
28 H_totalsup = 2950.4; // in kj per kg
29 H_totalsup = m * H_totalsup; // in kj
```

```

30 Q4 = H_totalsup - H_totalwet;// in kj
31 disp(Q4,"Part (iv) The quantity of heat in case
    forth in kJ is : ");

```

Scilab code Exa 9.5 Isentropic efficiency of turbine

```

1 // Exa 9.5
2 clc;
3 clear;
4 close;
5 // Given data
6 p1 = 2.5;// Mpa
7 p1 = p1 * 10^6;// in pa
8 p1 = p1 * 10^-5;// in bar
9 p2 = 10;// in kpa
10 p2 = p2 * 10^3;// in pa
11 p2 = p2 * 10^-5;// in bar
12 H1 = 2878;// in kJ/kg at 25 bar and 250 C
13 H2 = 2583.9;// in kJ/kg at 0.1 bar for dry saturated
    steam
14 AHD= H1-H2;// actual heat drop in kJ/kg
15 H2_desh = 2110;// in kj per kg
16 IHD = H1 - H2_desh;// Isentropic heat drop in kJ/ kg
17 Eta_Isentropic = (AHD/IHD) * 100;// in %
18 disp(Eta_Isentropic,"Isentropic efficiency in % is")
    ;
19 //  $H1 + \frac{v1^2}{2} + g*z1 + Q = H2 + \frac{v2^2}{2} + g*z2 + W$ 
20 W = H1 - H2;// in kJ/kg (as  $v1=v2$ ,  $z1= z2$  and  $Q=0$ )
21 disp(W,"Turbine work is in kJ/kg is :");

```

Scilab code Exa 9.6 Dryness fraction of steam

```

1 //Exa 9.6

```

```

2  clc;
3  clear;
4  close;
5  // Given data
6  p1 = 11; // in bar
7  p2 = 1.2; // in bar
8  H_w1 = 781.1; // in kJ/kg
9  L1 = 2000; // in kJ/kg
10 t1 = 120; // in degree c
11 t1 = t1 + 273; // in K
12 t2 = 104.81; // in degree c
13 t2 = t2 + 273; // in K
14 H_dry2 = 2683.4; // in kJ/kg
15 C_p = 2.607; // in kJ/kgK
16 // From  $H_{w1} + x \cdot L1 = H_{dry2} + C_p \cdot (t1 - t2)$ 
17 x = (H_dry2 + (C_p * (t1 - t2)) - H_w1) / L1;
18 disp(x, "Dryness fraction of steam is :");
19 x1 = (H_dry2 - H_w1) / L1;
20 disp(x1, "Maximum dryness fraction of steam is :");

```

Scilab code Exa 9.7 Dryness fraction of sample steam

```

1  //Exa 9.7
2  clc;
3  clear;
4  close;
5  // Given data
6  W = 21; // in kg
7  w_wp = 2; // in kg
8  h1 = 781.15; // in kJ/kg
9  L1 = 1998.5; // in kJ/kg
10 m = 2; // in kg
11 h2 = 420.5; // in kJ/kg
12 L = 2255.9; // in kJ/kg
13 t_sat = 100.4; // in degree c

```

```

14 t1 = 110; // in degree c
15 C_ps = 2; // in kJ/kgK
16 x1 = W / (W + w_wp);
17 x2 = (h2 + L + m * (t1-t_sat) - h1)/ L1;
18 x = x1 * x2;
19 disp(x,"The dryness fraction for sample steam is");

```

Scilab code Exa 9.8 Heat transfer during the process

```

1 //Exa 9.8
2 clc;
3 clear;
4 close;
5 // Given data
6 h_sen = 417.4; // in kJ/kg
7 h_totaldry = 2675.4; // in kJ/kg
8 L = 2258; // in kJ/kg
9 v = 5; // in m^3
10 v_v = 4.95; // in m^3
11 x = v_v/v;
12 Q = h_totaldry -(h_sen +x*L); // in kJ/kg
13 disp(Q,"Heat transfered per kg in kJ/kg is : ");

```

Scilab code Exa 9.9 Work done during evaporation

```

1 // Exa 9.9
2 clc;
3 clear;
4 close;
5 // Given data
6 m = 1; // in kg
7 p = 10; // in bar
8 p = p * 10^2; // in kpa

```

```

9 x = 0.94;
10 h_sen = 762.61; // in kJ/kg
11 L = 2013.6; // in kJ/kg
12 v_s = 0.1942; // in m^3 per kg
13 w_ext = p * x * v_s * m; // in kJ/kg
14 disp(w_ext, "The work done during evaporation in kJ/
    kg is");
15 // Part (b)
16 L_internal = (x * L) - w_ext; // in kJ/kg
17 disp(L_internal, "Internal latent heat in kJ/kg is");
18 // Part (c)
19 U_wet = h_sen + x * L - p * x * v_s; // in kJ/kg
20 disp(U_wet, "Internal energy in kJ/kg is");

```

Scilab code Exa 9.10 Entropy

```

1 // Exa 9.10
2 clc;
3 clear;
4 close;
5 // Given data
6 T_sat = 179.88; // in degree c
7 T_sat = T_sat + 273; // in k
8 T_sup = 200; // in degree c
9 T_sup = T_sup + 273; // in k
10 L = 2013.6; // in kJ/kg
11 C_ps = 2.326;
12 C_pw = 1;
13 x = 0.8;
14 phi_wet = C_pw * log(T_sat/273) + ( (x * L)/T_sat); //
    in kJ/kg-K
15 disp(phi_wet, "Entropy of wet steam in kJ/kg-K is");
16 // Part (b)
17 phi_dry = C_pw * log(T_sat/273) + L/T_sat; // in kJ/kg
18 disp(phi_dry, "Entropy of dry and saturated steam in

```



```

    kJ/kg-K is");
19 // Part (c)
20 phi_sup = phi_dry+C_ps *log(T_sup/T_sat);// in kJ/kg
21 disp(phi_sup,"Entropy at 200 C in kJ/kg-K is :");

```

Scilab code Exa 9.11 Volume of steam

```

1 // Exa 9.11
2 clc;
3 clear;
4 close;
5 // Given data
6 m = 1;// in kg
7 x = 0.9;
8 p = 1;// N/mm^2
9 p = p * 10^1;// in bar
10 p = p * 10^2;// in kPa
11 h_sen = 762.61;// in kJ/kg
12 L = 2013.6;// in kJ/kg
13 v_s = 0.1944;// in m^3 per kg
14 H_totalwet = h_sen + x*L;// in kJ/kg
15 U_wet = H_totalwet - (p * x * v_s);// in kJ/kg
16 I = U_wet / H_totalwet;// internal energy as a
    fraction of total heat
17 I = I * 10^2;// in %
18 disp(I,"The internal energy in % is");
19 // Part (b)
20 v_s = 0.1542;// in m^3/kg
21 h_sen = 815;// in kJ/kg
22 L = 1972;// in kJ/kg
23 H_totaldry = 2787;// in kJ/kg
24 C_ps = 2.199;
25 t_sup = 250;// in C
26 t_sup = t_sup + 273;// in K
27 t_sat = 190.74;// in C

```

```

28 t_sat = t_sat + 273; // in K
29 p1 = 13 * 10^2; // in kPa
30 v_ssup = v_s*t_sup/t_sat; // in m^3/kg
31 disp(v_ssup,"The volume of superheated steam in m^3/
    kg is");
32 // Part (c)
33 t_sat = t_sat - 273; // in C
34 t_sup = t_sup - 273; // in C
35 U_sup =h_sen+L+C_ps*(t_sup-t_sat)-p1*v_ssup; // in kJ
36 del_U = U_sup - U_wet; // in kJ
37 disp(del_U,"Change in internal energy in kJ is :");

```

Scilab code Exa 9.12 Condition of steam

```

1 // Exa 9.12
2 clc;
3 clear;
4 close;
5 // Given data
6 m = 0.5; // in kg
7 M = 6.6; // in kg
8 x1 = M / (M+m);
9 h_dry = 2683; //in kJ/kg
10 C_p = 2.1;
11 h_sen = 814.5; //in kJ/kg
12 L = 1973; // in kJ/kg
13 t_sup = 120; // in C
14 t_sat = 104.8; // in C
15 x2 =(h_dry+C_p*(t_sup - t_sat)-h_sen)/ L;
16 x = x2 * x1;
17 disp(x,"the dryness fraction of steam is");

```

Chapter 10

Steam Power Plant and Rankine Cycle

Scilab code Exa 10.1 Carnot efficiency

```
1 //Exa 10.1
2 clc;
3 clear;
4 close;
5 // Given data
6 p1 = 10; // in bar
7 p2 = 0.5; // in bar
8 T1 = 179.9; // in C
9 T1 = T1 + 273; // in K
10 T2 = 81.4; // in C
11 T2 = T2 + 273; // in K
12 Eta_carnot = (T1 - T2)/T1*100; // in %
13 disp(Eta_carnot, "Carnot efficiency of an engine when
    the steam is 0.87 dry in % is");
14 disp(Eta_carnot, "Carnot efficiency of an engine when
    the steam is dry saturated in % is");
15 T1 = T1 + 50; // in K
16 Eta_carnot1 = (T1 - T2) / T1*100; // in %
17 disp(Eta_carnot1, "Carnot efficiency of an engine
```

when the steam is superheated in % is");

Scilab code Exa 10.2 Heat supplied to the boiler

```
1 // Exa 10.2
2 clc;
3 clear;
4 close;
5 // Given data
6 h1 = 3015; // in kJ/kg
7 h2 = 2326; // in kJ/kg
8 h3 = 113; // in kJ/kg
9 h4 = 114.95; // in kJ/kg
10 Q = h1 - h4; // in kJ/kg
11 disp(Q,"Heat supplied to the boiler in kJ/kg is");
12 W_T = h1 - h2; // in kJ/kg
13 disp(W_T,"Work developed by turbine in kJ/kg is : ")
    ;
14 W_P = ( h1 - h3) - Q; // in kJ/kg
15 disp(W_P,"Work absorbed by pump in kJ/kg is : ");
16 Eta = (W_T - W_P)/Q*100; // in %
17 disp(Eta,"Efficiency of flow system in % is : ");
```

Scilab code Exa 10.3 Percentage increase in Rankine efficiency

```
1 // Exa 10.3
2 clc;
3 clear;
4 close;
5 // Given data
6 phi_s = 6.583;
7 phi_w = 1.091;
8 phi_s1 = 6.504;
```

```

9 C_p = 2.25;
10 T_sat =179.9; // in C
11 T_sat = T_sat + 273; // in K
12 T_sup = T_sat + 50; // in K
13 x2 = (phi_s - phi_w)/phi_s1;
14 H1 = 2776.2; // in kJ/kg
15 H_w2 = 340.6; // in kJ/kg
16 L2 = 2305;
17 H2 = H_w2 + (x2 * L2); // in kJ/kg
18 Eta_rankine = (H1 - H2)/(H1 - H_w2)*100; // in %
19 disp(Eta_rankine,"Rankine efficiency in % is");
20 phi_w1 = 2.138;
21 x1 = 0.87;
22 phi_s1 = 4.445;
23 phi_w2 = 1.091;
24 phi_s2 = 6.504;
25 x2 = (phi_w1 + (x1 * phi_s1) - phi_w2) / phi_s2;
26 H1 = 762.6 + (x1 * 2013.6); // in kJ/kg
27 H2 = 340.6 + (x2 * 2305); // in kJ/kg
28 Eta_rankine1 = (H1 - H2) / (H1 - H_w2)*100; // in %
29 PerDropInRankine= (Eta_rankine - Eta_rankine1)/
    Eta_rankine * 100; // in %
30 disp(PerDropInRankine,"Percentage drop in Rankine
    efficiency in % is : ");
31 phi_s1 = 6.583;
32 phi_w1 = 1.091;
33 phi_s2 = 6.504;
34 x2 = (phi_s1 + C_p * log(T_sup/T_sat) - phi_w1)/
    phi_s2;
35 H_s1 = 2776.2;
36 H1 = H_s1 + C_p * (T_sup - T_sat); // in kJ/kg
37 H2 = 340.6 + (0.88 * 2305); // in kJ/kg
38 H_w2 = 340.6;
39 Eta_rankine2 = (H1 - H2) / (H1 - H_w2);
40 Eta_rankine2 = Eta_rankine2 * 10^2; // in percentage
41 PerIncInRank = ((Eta_rankine2 - Eta_rankine)/
    Eta_rankine2) * 100; // in percentage
42 disp(PerIncInRank,"Percentage increase in rankine

```

efficiency in % is :");

Scilab code Exa 10.4 Thermal efficiency of the cycle

```
1 //Exa 10.4
2 clc;
3 clear;
4 close;
5 // Given data
6 H2 = 2776.2; // in kJ/kg
7 p1 = 10; // in bar
8 p_2 = 1; // in bar
9 p_3 = 0.25; // in bar
10 p_4 = p_3; // in bar
11 // w = (H2 - H_2) + ((p_2 - p_3) * v_2); // work done
    in kJ/kg
12 phi_2 = 6.583;
13 phi_d2 = 1.303;
14 L = 6.057;
15 x_2 = (phi_2 - phi_d2) / L;
16 H2_desh = 417.5 + (x_2 * 2257.9); // in kJ/kg
17 v_s = 1.694;
18 v_2 = x_2 * v_s; // in m^3 per kg
19 w = (H2 - H2_desh) + ((p_2 - p_3) * v_2); // in kJ/kg
20 H4 = 282.7; // in kJ/kg
21 H_w4 = H4; // in kJ/kg
22 HeatSupplied = H2 - H4; // kJ/kg
23 Eta_modifiedRankine = w / HeatSupplied * 100; // in %
24 disp(Eta_modifiedRankine, "Thermal efficiency of
    the cycle in % is : ");
25 HeatRemoved = HeatSupplied - w; // in kJ/kg
26 disp(HeatRemoved, "Heat removed in condenser in kJ/kg
    is : ");
```

Scilab code Exa 10.13 Work output per kg

```
1 // Exa 10.13
2 clc;
3 clear;
4 close;
5 // Given data
6 Q = 1100; // in kW
7 m=1; // in kg
8 p1 = 15; // in bar
9 p1 = p1 * 10^5; // in Pa
10 p1 = p1 * 10^-3; // in kPa
11 p2 = 0.05 * 10^2; // in kPa
12 v1 = 0.16; // m^3 per kg
13 v2 = 26; // in m^3 per kg
14 V1 = 110; // in m per s
15 V2 = 120; // in m per s
16 u1 = 2935; // in kJ per kg
17 u2 = 1885; // in kJ per kg
18 g = 9.8;
19 z1 = 0;
20 z2 = 0;
21 // Formula  $Q-W = m\{(u_2 - u_1) + (p_2*v_2 - p_1*v_1) + 1/2*(V_2^2 - V_1^2) + g*(z_2 - z_1)\}$ 
22 W = Q - m * {(u2 - u1) + (p2*v2 - p1*v1) + 1/2*(V2^2 - V1^2) + g
    *(z2 - z1)}; // in kW
23 disp(W, "Work output per kg in kW is");
24 SteamFlowRate = Q / W; // in kg/sec
25 SteamFlowRate = SteamFlowRate * 3600; // in kg per hr
26 disp(SteamFlowRate, "Steam flow rate in kg/hr is");
```

Scilab code Exa 10.14 Ratio of mass flow rate of cooling water to condensing steam

```
1 // Exa 10.14
2 clc;
3 clear;
4 close;
5 // Given data
6 h_sen = 191.9; // in kJ/kg
7 L = 2392; // in kJ/kg
8 x = 0.95;
9 t_o = 35; // in C
10 t_i = 20; // in C
11 C = 4.18;
12 H_totalwet = h_sen + (x * L); // in kJ/kg
13 // m_steam * (H_totalwet - h_sen) = m_water * C * (
    t_o - t_i)
14 msBYmw = (H_totalwet - h_sen) / (C * (t_o - t_i));
    //
15 disp(msBYmw, "The Ratio of mass flow rate of cooling
    water to condensing steam is : ");
```

Chapter 11

Introduction to Working of IC Engines

Scilab code Exa 11.1 Capacity of the engine

```
1 // Exa 11.1
2 clc;
3 clear;
4 close;
5 // Given data
6 n = 3;
7 l = 80; // in mm
8 d = 76; // in mm
9 r = 8.5;
10 V_s = (%pi/4) * d * d * l; // in mm^3
11 V_s = V_s * 10^-3; // in cm^3
12 // r = 1+ (V_s/V_c)
13 V_c = (1/(r - 1)) * V_s; // in cm^3
14 disp(V_c*10^3, "Clearance volume of cylinder in mm^3
    is : ");
15 C = V_s * n; // C stands for capacity of engine in cm
    ^3
16 C = C * 10^-3; // in litre
17 disp(C, "Capacity of the engine in litre is :");
```

